PRINCIPLES OF INHERITANCE AND VARIATION

BASIC CONCEPTS

1. **Mendel's Laws of Inheritance:** Mendel proposed the laws of inheritance. His theory was rediscovered by Hugo de Vries of Holland, Carl Correns of Germany and Eric von Tschermak of Austria.

   (*i*) **Law of dominance:** This law states that when two alternative forms of a trait or character (genes or alleles) are present in an organism, only one factor expresses itself in F_1 progeny and is called dominant while the other that remains masked is called recessive.

   (ii) **Law of segregation or law of purity of gametes:** This law states that the factors or alleles of a pair segregate from each other during gamete formation, such that a gamete receives only one of the two factors. They do not show any blending but simply remain together.

   (*iii*) **Law of independent assortment:** According to this law the two factors of each character assort or separate out independent of the factors of other characters at the time of gamete formation and get randomly rearranged in the offsprings producing both parental and new combinations of characters.

2. **Incomplete dominance:** It is a phenomenon in which the F_1 hybrid exhibits characters intermediate of the parental genes. Here, the phenotypic ratio deviates from the Mendel's monohybrid ratio (1 : 2 :1).

3. **Co-dominance:** The alleles which are able to express themselves independently, even when present together are called co-dominant alleles and this biological phenomenon is called co-dominance.

4. **Test cross:** It is a method devised by Mendel to determine the genotype of an organism.

   In this cross, the organism with dominant phenotype (but unknown genotype) is crossed with the recessive individual.

5. **Pleiotropy:** It is the phenomenon in which a single gene exhibits or controls multiple phenotypic expressions.

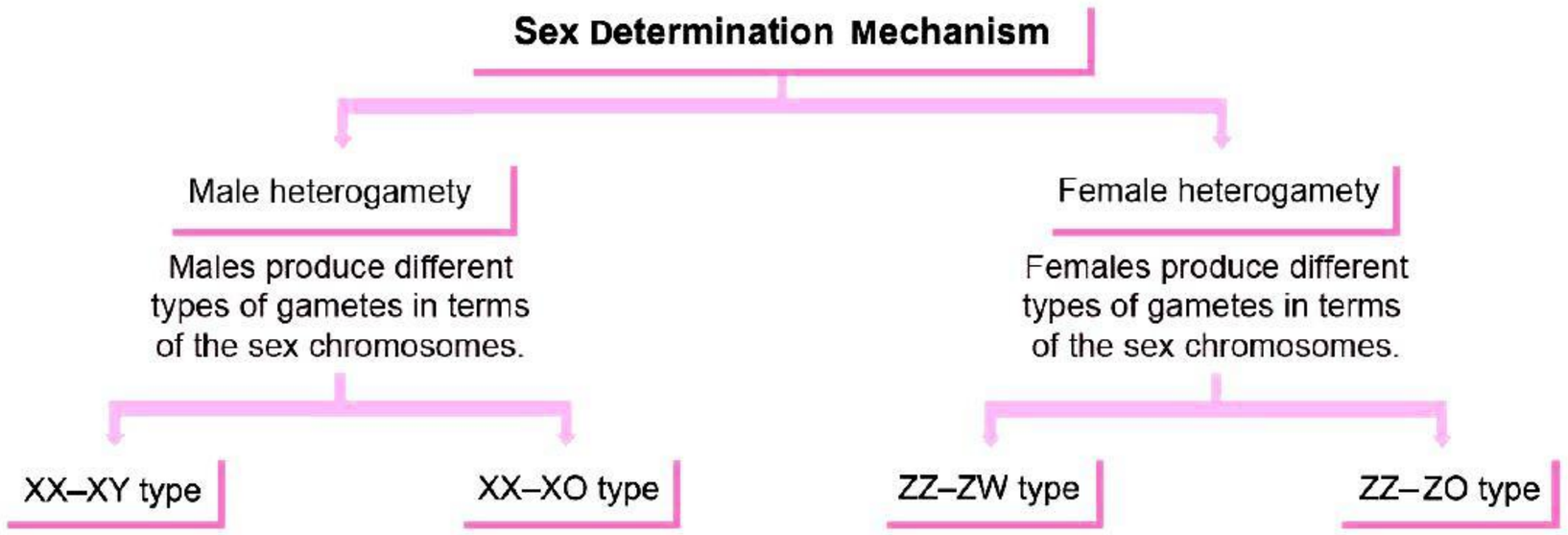
   - The pleiotropic gene affects the metabolic pathways, resulting in different phenotypes.
   - For example, phenylketonuria is caused by mutation in the gene coding for the enzyme phenylalanine hydroxylase. The affected individuals show mental retardation as well as reduction in hair and skin pigmentation.

6. **Polygenic inheritance:** It is a type of inheritance, in which a trait is controlled by three or more genes. Such traits are called **polygenic traits**. The phenotype reflects contribution of each allele and is also influenced by the environment.

7. **Chromosomal theory of inheritance:** The chromosomal theory of inheritance was proposed independently by **Walter Sutton** and **Theodore Boveri** in 1902. They stated that behaviour of chromosomes was parallel to behaviour of genes and used chromosome movement to explain Mendel's laws.

8. **T. H. Morgan** carried out several dihybrid crosses in *Drosophila* to study the genes that are sex-linked. He observed that when the two genes in a dihybrid cross are located on the same chromosome, the proportion of parental gene combinations in the progeny was much higher than the non-parental or recombination of genes.

9. Alfred Sturtevant determined that genes of *Drosophila* are arranged in a linear order. He measured the distance between genes and prepared **chromosome maps** with the position of genes on the chromosomes based on percentage of recombinants. These are also called **genetic maps**.
10. Two types of chromosomes are present in individuals – **sex chromosomes** (which determine the sex of individuals) and **autosomes**.



11. Honeybees show haplodiploid sex determination system. Offsprings formed from union of a sperm and an egg develops as a female (**queen or worker**), which are diploid, having 32 chromosomes. Unfertilised eggs developed by parthenogenesis form male (**drone**), which are haploid having 16 chromosomes.
12. **Mutation** is defined as the sudden inheritable change in the genetic material. It can be of the following two major types:
    (*i*) **Point mutation:** It is the mutation in a single base pair, which is replaced by another base pair. For example, in sickle-cell anaemia, point mutation in β-globin chain results in change of glutamate to valine.
    (*ii*) **Frameshift mutation:** It is the change in the reading frame because of insertion or deletion of base pairs.
        (*a*) **Insertion:** It is the addition of one or more nucleotides in the DNA segment. Insertion of three or its multiple bases do not change the reading frame but add a new amino acid.
        (*b*) **Deletion:** It is the removal of one or more nucleotides from the DNA segment. Deletion of three or its multiple bases do not change the reading frame but remove one or more amino acids.

        Normal DNA: ATC GAT CGA

        Insertion: ATC CGA TCG

        Deletion: ATC ATC GA
13. **Mendelian disorders:** Mendelian disorders are caused due to alteration or mutation in single gene.
    (*i*) **Haemophilia:**
        (*a*) It is a sex-linked recessive disorder.
        (*b*) Patient continues to bleed even with a minor cut because of a defect in blood coagulation.
        (*c*) The gene for haemophilia is located on X chromosome.
        (*d*) More males suffer from haemophilia than females because in males single gene for the defect is able to express as males have only one X chromosome.
    (*ii*) **Sickle-cell anaemia**
        (*a*) It is an autosome-linked recessive trait.
        (*b*) The disease is controlled by a single pair of allele Hb^A and Hb^S.
        (*c*) Due to point mutation, glutamic acid (Glu) is replaced by valine (Val) at the sixth position of β-globin chain of haemoglobin molecule.

(*iii*) Phenylketonuria

(*a*) It is an inborn error of metabolism and is inherited as autosomal recessive trait.

(*b*) The affected individual lacks an enzyme called phenylalanine hydroxylase that converts the amino acid phenylalanine into tyrosine in liver.

(*iv*) Thalassemia

(*a*) It is an autosome-linked recessive disease.

(*b*) It occurs due to either mutation or deletion resulting in reduced rate of synthesis of one of globin chains of haemoglobin.

(*c*) Thalassemia is classified into two types:

- α thalassemia Production of α globin chain is affected. It is controlled by the closely linked genes *HbA1* and *HbA2* on chromosome 16. It occurs due to mutation or deletion of one or more of the four genes.
- β-thalassemia—Production of β-globin chain is affected. It occurs due to mutation of one or both *HbB* genes on chromosome 11.

(*v*) Colour blindness

(*a*) It is a sex-linked recessive disorder.

(*b*) The gene for colour blindness is present on X chromosome.

14. Chromosomal disorders: Chromosomal disorders are caused due to excess, absence or abnormal arrangement of one or more chromosomes.

(*i*) Down's syndrome:

Cause: Additional copy of chromosome number 21 or trisomy of chromosome 21.

Symptoms:

(*i*) Short statured with small round head

(*ii*) Partially open mouth with protruding furrowed tongue

(*iii*) Palm is broad with characteristic palm crease

(*iv*) Physical, psychomotor and mental development retarded

(*ii*) Klinefelter's syndrome

Cause: Presence of an additional copy of X chromosome resulting in the karyotype 44+XXY *i.e.*, 47 chromosomes.

Symptoms:

(*i*) Sex of the individual is masculine but possess feminine characters

(*ii*) Gynaecomastia, *i.e.*, development of breasts

(*iii*) Poor beard growth and often sterile

(*iv*) Feminine pitched voice

(*v*) They are sterile

(*vi*) Tall stature

(*iii*) Turner's syndrome

Cause: Absence of one of the X chromosomes, resulting in the karyotype 44+XO *i.e.*, have 45 chromosomes.

Symptoms:

(*i*) Sterile female with rudimentary ovaries

(*ii*) Lack of other secondary sexual characters

(*iii*) Underdeveloped feminine characters

(*iv*) Poor development of breasts

(*v*) Short stature, small uterus, puffy fingers

MULTIPLE CHOICE QUESTIONS

Choose and write the correct option in the following questions.

1. Which one of the following is an example of polygenic inheritance?

(*a*) Skin colour in humans
(*b*) Flower colour in *Mirabilis jalapa*
(*c*) Production of male honey bee
(*d*) Pod shape in garden pea

2. In Mendel's experiments with garden pea, round seed shape (RR) was dominant over wrinkled seeds (rr) and yellow cotyledon (YY) was dominant over green cotyledon (yy). Which of the following are the expected phenotypes in the F_2 generation of the cross RRYY × rryy?

(*a*) Round seeds with yellow cotyledons, and wrinkled seeds with yellow cotyledons
(*b*) Only round seeds with green cotyledons
(*c*) Only wrinkled seeds with yellow cotyledons
(*d*) Only wrinkled seeds with green cotyledons

3. Test cross involves

(*a*) crossing between two genotypes with dominant trait
(*b*) crossing between two genotypes with recessive trait
(*c*) crossing between two F_1 hybrids
(*d*) crossing the F_1 hybrid with a double recessive genotype

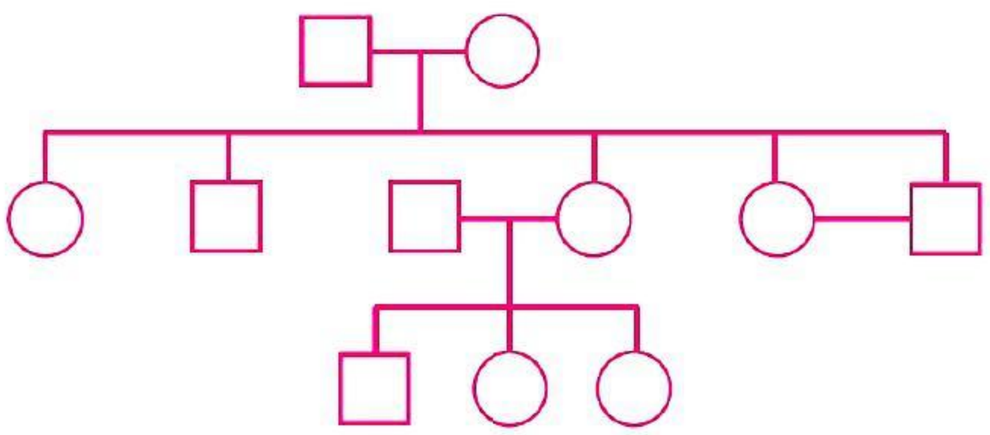
4. If a colour blind woman marries a normal visioned man, their sons will be

(*a*) all colour blind
(*b*) all normal visioned
(*c*) one-half colour blind and one-half normal
(*d*) three-fourths colour blind and one-fourth normal

5. Inheritance of skin colour in humans is an example on

(*a*) point mutation
(*b*) polygenic inheritance
(*c*) co-dominance
(*d*) chromosomal aberration

6. Study the pedigree chart given below. What does it show?



(*a*) Inheritance of a condition like phenylketonuria as an autosomal recessive trait.
(*b*) The pedigree chart is wrong as this is not possible.
(*c*) Inheritance of a recessive sex-linked disease like haemophilia.
(*d*) Inheritance of a sex-linked inborn error of metabolism like phenylketonuria.

7. All genes located on the same chromosome *[NCERT Exemplar]*

(*a*) form different groups depending upon their relative distance
(*b*) form one linkage group
(*c*) will not form any linkage groups
(*d*) form interactive groups that affect the phenotype

8. **Conditions of a karyotype $2n + 1$, $2n - 1$ and $2n + 2$, $2n - 2$ are called** [*NCERT Exemplar*]

(*a*) aneuploidy (*b*) polyploidy

(*c*) allopolyploidy (*d*) monosomy

9. **Distance between the genes and percentage of recombination shows** [*NCERT Exemplar*]

(*a*) a direct relationship (*b*) an inverse relationship

(*c*) a parallel relationship (*d*) no relationship

10. **If a genetic disease is transferred from a phenotypically normal but carrier female to only some of the male progeny, the disease is** [*NCERT Exemplar*]

(*a*) autosomal dominant (*b*) autosomal recessive

(*c*) sex-linked dominant (*d*) sex-linked recessive

11. **If a plant heterozygous for tallness is selfed, the F_2 generation has both tall and dwarf plants. It proves the principle of**

(*a*) dominance (*b*) segregation

(*c*) independent assortment (*d*) incomplete dominance

12. **In sickle cell anaemia, glutamic acid is replaced by valine. Which one of the following triplets codes for valine?** [*NCERT Exemplar*]

(*a*) G G G (*b*) A A G

(*c*) G A A (*d*) G U G

13. **Person having genotype $I^A I^B$ would show the blood group as AB. This is because of** [*NCERT Exemplar*]

(*a*) pleiotropy (*b*) co-dominance

(*c*) segregation (*d*) incomplete dominance

14. **ZZ/ZW type of sex determination is seen in** [*NCERT Exemplar*]

(*a*) platypus (*b*) snails

(*c*) cockroach (*d*) peacock

15. **A cross between two tall plants resulted in offspring having few dwarf plants. What would be the genotypes of both the parents?** [*NCERT Exemplar*]

(*a*) TT and Tt (*b*) Tt and Tt

(*c*) TT and TT (*d*) Tt and tt

16. **In a dihybrid cross, if you get 9:3:3:1 ratio it denotes that** [*NCERT Exemplar*]

(*a*) the alleles of two genes are interacting with each other

(*b*) it is a multigenic inheritance

(*c*) it is a case of multiple allelism

(*d*) the alleles of two genes are segregating independently

17. **Which of the following will not result in variations among siblings?**

(*a*) Independent assortment of genes (*b*) Crossing over

(*c*) Linkage (*d*) Mutation

18. **What will never be father's blood group if the mother has blood group B and child has blood group O?**

(*a*) A (*b*) B

(*c*) AB (*d*) O

19. Mendel's Law of independent assortment holds good for genes situated on the [*NCERT Exemplar*]

(*a*) non-homologous chromosomes (*b*) homologous chromosomes

(*c*) extra nuclear genetic element (*d*) same chromosome

20. Occasionally, a single gene may express more than one effect. The phenomenon is called [*NCERT Exemplar*]

(*a*) multiple allelism (*b*) mosaicism

(*c*) pleiotropy (*d*) polygeny

21. In a certain taxon of insects some have 17 chromosomes and the others have 18 chromosomes. The 17 and 18 chromosome bearing organisms are [*NCERT Exemplar*]

(*a*) males and females, respectively (*b*) females and males, respectively

(*c*) all males (*d*) all females

22. The inheritance pattern of a gene over generations among humans is studied by the pedigree analysis. Character studied in the pedigree analysis is equivalent to [*NCERT Exemplar*]

(*a*) quantitative trait (*b*) Mendelian trait

(*c*) polygenic trait (*d*) maternal trait

23. It is said that Mendel proposed that the factor controlling any character is discrete and independent. His proposition was based on the [*NCERT Exemplar*]

(*a*) results of F_3 generation of a cross

(*b*) observations that the offspring of a cross made between the plants having two contrasting characters shows only one character without any blending

(*c*) self pollination of F_1 offsprings

(*d*) cross pollination of F_1 generation with recessive parent

24. Which of the following represents a pair of contrasting characters?

(*a*) Allele (or allelomorphs) (*b*) Phenotype

(*c*) Homozygous (*d*) Heterozygous

25. Two genes 'A' and 'B' are linked. In a dihybrid cross involving these two genes, the F_1 heterozygote is crossed with homozygous recessive parental type (aabb). What would be the ratio of offspring in the next generation? [*NCERT Exemplar*]

(*a*) 1 : 1 : 1: 1 (*b*) 9 : 3 : 3 : 1

(*c*) 3 : 1 (*d*) 1 : 1

26. In the F_2 generation of a Mendelian dihybrid cross the number of phenotypes and genotypes are [*NCERT Exemplar*]

(*a*) phenotypes - 4; genotypes - 16 (*b*) phenotypes - 9; genotypes - 4

(*c*) phenotypes - 4; genotypes - 8 (*d*) phenotypes - 4; genotypes - 9

27. Which of the following acts as vehicle of genetic material?

(*a*) Nucleosome (*b*) Centrosomes

(*c*) Ribosomes (*d*) Chromosomes

28. The allelic pair which does not express in the presence of other allelic pair is called as

(*a*) hypostatic (*b*) epistatic

(*c*) recessive (*d*) complementary

29. The scientist who converted Mendel's work into laws of genetics was

(*a*) Carl Correns (*b*) Hugo de Vries

(*c*) Tschermak (*d*) Morgan

30. The term 'factor' for gene was proposed by

(*a*) Correns (*b*) Mendel

(*c*) Tschermark (*d*) Morgan

31. Organisms phenotypically similar but genotypically dissimilar are due to the phenomenon of

(*a*) mutations (*b*) heterozygosity

(*c*) homozygosity (*d*) monozygosity

32. The gene controlling the seven different characters of pea, studied by Mendel are now known to be located on how many different chromosomes?

(*a*) 1 pair (*b*) 2 pair

(*c*) 3 pair (*d*) 4 pair

33. The four daughter cells (*n*) derived from a single meiosis differ from each other due to

(*a*) difference in chromosome number

(*b*) crossing over only

(*c*) independent assortment of chromosomes only

(*d*) crossing over as well as independent assortment of chromosomes

34. ABO blood group system is seen to occur in

(*a*) human beings and monkeys (*b*) human beings and species of primates

(*c*) monkeys and primates (*d*) all of the above

35. The F_1 generation in Mendelian crosses is always

(*a*) homozygous (*b*) heterozygous

(*c*) both (*a*) and (*b*) (*d*) none of the above

36. Genome is

(*a*) diploid set of chromosomes (*b*) haploid set of chromosomes

(*c*) another term for gene pool (*d*) none of the above

37. Which of the following is the only universally true law of Mendel?

(*a*) Law of dominance (*b*) Law of segregation

(*c*) Law of purity of gametes (*d*) Both (*b*) and (*c*)

38. Which of the following is the exception to the law of independent assortment?

(*a*) Crossing over (*b*) Linkage

(*c*) Recombination (*d*) Epistasis

39. The term 'gene' was proposed by

(*a*) Morgan (*b*) Mendel

(*c*) Bateson (*d*) Johanssen

40. The term 'genetics' was introduced by

(*a*) Morgan (*b*) Mendel

(*c*) Correns (*d*) Bateson

41. The term 'genotype' was introduced by

(*a*) Johanssen (*b*) Castle

(*c*) Correns (*d*) Morgan

42. The term 'homozygous' was introduced by

(*a*) Bateson (*b*) Johanssen

(*c*) Saunders (*d*) both (*a*) and (*c*)

43. In the monohybrid cross, the test cross ratio of a heterozygous individual results in the ratio of

(*a*) 9 : 3 : 3 : 1 (*b*) 1 : 1

(*c*) 1 (*d*) 1 : 1 : 1 : 1

44. The number of genotypic recombinations possible due to the 3 alleles in case of human blood group system are

(*a*) 4 (*b*) 6

(*c*) 8 (*d*) 12

45. In biparental reproduction, the offspring

(*a*) differs from both the parents

(*b*) shows no change from the maternal parent

(*c*) shows no change from the paternal parent

(*d*) shows mixtures of characters from both parents

46. Mendel was

(*a*) a physiologist (*b*) a plant breeder

(*c*) a cytologist (*d*) a taxonomist

47. Mendel is famous for his experiments on

(*a*) *Pisum sativum* (*b*) *Drosophila melanogaster*

(*c*) *Neurospora crassa* (*d*) *Oenothera lamarckiana*

48. The geometrical device which helps in visualizing all the possible combinations of male and female gametes is called

(*a*) Bateson square (*b*) Mendel square

(*c*) Punnett square (*d*) Payen's square

49. Segregation of hereditary factors occur in plants during the process of

(*a*) spore formation (*b*) gamete formation

(*c*) fertilisation (*d*) disjunction

50. An offspring of two homozygous parents differing from one another by alleles at only one gene locus is known as

(*a*) back cross (*b*) monohybrid

(*c*) dihybrid (*d*) trihybrid

51. Number of characters studied in garden pea by Mendel were

(*a*) five (*b*) three

(*c*) six (*d*) seven

52. The process of removing stamens from the flower bud during hybridisation is called

(*a*) crossing (*b*) selfing

(*c*) emasculation (*d*) copying

53. Which of the following characters of pea was not studied by Mendel?

(*a*) Length of plant (*b*) Size of seed

(*c*) Colour of pod (*d*) Shape of pod

54. Most extensively studied material in genetics is

(*a*) *E.coli* (*b*) Maize

(*c*) Pea (*d*) *Drosophila*

55. In a cross YYRr × YyRR, the offspring will show the genotypic ratio

(*a*) 2 YyRR : 2 YYRR
(*b*) 1 YYRR : 3 YyRR
(*c*) 4 YYRR : 0 yyRR
(*d*) None of the above

56. What blood group found in offspring in a marriage between blood group A man and blood group AB woman will prove man to be heterozygous?

(*a*) Blood group A
(*b*) Blood group B
(c) Blood group AB
(*d*) Blood group O

57. Two normally pigmented parents have an albino child. Their second child is normally pigmented. What is the probability that third child is an albino?

(*a*) $\frac{1}{4}$
(*b*) $\frac{1}{8}$
(*c*) $\frac{1}{2}$
(*d*) 1

58. A hybrid red coloured plant was selfed and 1600 seeds were produced. How many will be red in colour?

(*a*) 1200
(*b*) 1600
(*c*) 800
(*d*) 400

59. What will be the probability of a child born to parents having blood group AB and blood group AB to be blood group AB?

(*a*) $\frac{1}{8}$
(*b*) $\frac{1}{16}$
(*c*) $\frac{1}{4}$
(*d*) $\frac{1}{2}$

60. What will be the genotype of the normally pigmented woman who if marries an albino man produces a normal offspring and an albino offspring in the ratio 1 : 1?

(*a*) Homozygous
(*b*) Heterozygous
(*c*) Both (*a*) and (*b*)
(*d*) Information incomplete

61. Segregation of genes occur in

(*a*) Anaphase I
(*b*) Anaphase II
(*c*) Metaphase I
(*d*) Telophase I

62. How many out of 10 million sperms in a man with genotype AaBb will have both recessive alleles?

(*a*) 2.5 million
(*b*) 5 million
(*c*) 7.5 million
(*d*) 10 million

63. If a plant with genotype $R_1R_1R_0R_0$ produces potatoes of 240 gram weight, while $r_1r_1r_0r_0$ produces potatoes 100 grams in weight. What will be the weight of potatotes in a plant $R_1R_1R_0r_0$?

(*a*) 215 g
(*b*) 225 g
(*c*) 205 g
(*d*) 195 g

64. If Mendel had studied the 7 traits using a plant with 12 chromosomes instead of 14, how could have his interpretations varied?

(*a*) He would have not discovered law of segregation.
(*b*) He would not have discovered law of independent assortment.
(*c*) Both (*a*) and (*b*)
(*d*) None of the above

65. 1 : 2 : 1 is a ratio which is found in

(*a*) F_2 geneotypic ratio of a dihybrid cross (*b*) co-dominance

(*c*) incomplete dominance (*d*) all of the above

66. In case of multiple allelism dealing with human blood groups, what is the probability of a child born to blood group A mother and blood group B father to have blood group O?

(*a*) $\frac{1}{4}$ (*b*) 0

(*c*) $\frac{1}{16}$ (*d*) $\frac{3}{8}$

67. What is the probability of a child born to blood group AB mother and blood group O father to have blood group A?

(*a*) $\frac{1}{2}$ (*b*) $\frac{1}{4}$

(*c*) $\frac{1}{8}$ (*d*) 0

68. What is the probability of a man with blood group AB and a woman with blood group O having a blood group AB child?

(*a*) 0 (*b*) $\frac{1}{2}$

(*c*) $\frac{1}{4}$ (*d*) $\frac{1}{8}$

69. A child has blood group A and his mother has blood group O. What is the probability that a man having blood group AB claiming to be the father is saying the truth?

(*a*) $\frac{1}{2}$ (*b*) $\frac{1}{4}$

(*c*) 0 (*d*) $\frac{1}{16}$

70. In a selfing type of cross, each parent contributes 32 types of gametes. How many boxes will be present in the Punnett square of such a cross?

(*a*) 32 (*b*) 640

(*c*) 1024 (*d*) 3096

71. In a selfing type of cross, 81 types of genotypes are produced. How many types of phenotypes will be present?

(*a*) 32 (*b*) 16

(*c*) 64 (*d*) 128

72. How many types of phenotypes will be produced in a cross involving genotypes AaBbCcDd × AaBbCcDd?

(*a*) 4 (*b*) 16

(*c*) 64 (*d*) 32

73. At which stage of cell division, the chromosomes are most distinct?

(*a*) Interphase (*b*) Prophase

(*c*) Metaphase (*d*) Anaphase

74. Son receives X-chromosome from

(*a*) father (*b*) mother

(*c*) both (*a*) and (*b*) (*d*) none of these

75. Daughter receives X-chromosome from

(*a*) father (*b*) mother

(*c*) both (*a*) and (*b*) (*d*) Either (*a*) or (*b*)

76. X-linked traits are inherited from mother to

(*a*) son (*b*) daugher

(*c*) both (*a*) and (*b*) (*d*) none of these

77. Y-linked traits are inherited from father to

(*a*) son (*b*) daugher

(*c*) both (*a*) and (*b*) (*d*) none of these

78. Gene for colour-blindness is

(*a*) X-linked recessive (*b*) X-linked dominant

(*c*) Y-linked (*d*) autosomal

79. Gene for haemophilia is

(*a*) X-linked recessive (*b*) X-linked dominant

(*c*) Y-linked (*d*) autosomal

80. Which of the following statements is false?

(*a*) Crossing the F_1 hybrid with a homozygous recessive individual is called test cross.

(*b*) For sex-linked traits, reciprocal crosses don't give the same result.

(*c*) Test cross distinguishes homozygosity and heterozygosity of a trait.

(*d*) None of these

81. The males of grasshoppers and bugs have

(*a*) one Y-chromosome (*b*) one X-chromosome

(*c*) neither X nor Y-chromosome (*d*) one X and one Y-chromosome

82. One way of determining sex-linked inheritance is

(*a*) both son and daughter resemble mother

(*b*) son resembles father and daughter resembles mother

(*c*) both son and daughter resemble father

(*d*) son resembles mother and daughter resembles father

83. Klinefelter's syndrome is due to

(*a*) 21^{st} trisomy (*b*) additional copy of X chromosome

(*c*) monosomy of X chromosome (*d*) 18^{th} trisomy

84. Down's syndrome is due to

(*a*) 21^{st} trisomy (*b*) trisomy of sex chromosome

(*c*) monosomy of sex chromosome (*d*) 18^{th} trisomy

85. Turner's syndrome is due to

(*a*) 21^{st} trisomy (b) trisomy of X chromosome

(*c*) monosomy of X chromosome (*d*) 18^{th} trisomy

86. Klinefelter's syndrome is represented by genotype

(*a*) 44+XO (*b*) 44+XXY

(*c*) 44+XXX (*d*) an extra chromosome in 21^{st} pair

87. Down's syndrome is represented by genotype

(*a*) 44+XO (*b*) 44+XXY

(*c*) 44+XXX (*d*) an extra chromosome in 21st pair

88. Identify the incorrect statement.

(*a*) Usually female birds produce two types of gametes in relation to sex.

(*b*) In *Drosophila* sex is determined by X chromosome and autosome.

(*c*) In honey bee, workers are haploid.

(*d*) In male grasshoppers 50% of the sperms have no sex chromosome.

89. Sex determination in *Drosophila melanogaster* is based on

(*a*) ratio between X and Y chromosome

(*b*) X, Y-chromosome mechanism

(*c*) genetic balance between the X-chromosome and autosomes

(*d*) chromosome environment interaction

90. A family has 5 daughters. Probability of 6th child being girl will be

(*a*) 1 in 2 (*b*) 1 in 5

(*c*) 1 in 3 (*d*) 1 in 6

91. Sex of a human child is determined by

(*a*) strength of the sperm (*b*) time of fertilisation

(*c*) sex chromosome of father (*d*) sex chromosome of mother

92. Match the items of column I with that of column II.

Column I	Column II
A. Sex-linked	1. Baldness
B. Sex-influenced	2. AIDS
C. Sex-limited	3. Klinefelter's syndrome
	4. Colour blindness
	5. Milk production in human

(*a*) A—4, B—3, C—2 (*b*) A—5, B—3, C—2

(*c*) A—5, B—1, C—3 (*d*) A—4, B—1, C—5

93. 2A + XO *Drosophila* is

(*a*) sterile male (*b*) intersex

(*c*) fertile female (*d*) infertile female

94. Sex chromosomes of a female bird are represented by

(*a*) ZO (*b*) XX

(*c*) XO (*d*) ZW

95. Chromosome number of individual with Down's syndrome is

(*a*) 47 (*b*) 46

(*c*) 23 (*d*) 45

96. Chromosome number of female with Turner's syndrome is

(*a*) 47 (*b*) 46

(*c*) 23 (*d*) 45

97. Down's syndrome is due to

(*a*) non-disjunction of chromosome
(*b*) sex-linked inheritance
(*c*) crossing over
(*d*) linkage

98. A man has enlarged breasts, sparse hairs on the body and sex chromosomal formula XXY. He then suffers from

(*a*) Down's syndrome
(*b*) Edward's syndrome
(*c*) Turner's syndrome
(*d*) Klinefelter's syndrome

99. How many autosomes are present in somatic cells of a normal female?

(*a*) 22
(*b*) 44
(*c*) 23
(*d*) 46

100. Two organisms with a genotype of HhYy(H-height, Y-colour) were mated. What is the probability for the offsprings to carry only one of the dominant characters?

(*a*) 1/4
(*b*) 1/16
(*c*) 4/16
(*d*) 6/16

101. How many genotypes can be produced by two alleles T and t?

(*a*) 3
(*b*) 4
(*c*) 1
(*d*) 2

102. If a female physically develops male secondary sexual characters, the syndrome is called

(*a*) Turner's syndrome
(*b*) Down's syndrome
(*c*) Klinefelter's syndrome
(*d*) Super female

103. Which of the following shows pleiotropic effect?

(*a*) Skin colour in human being
(*b*) Colour blindness
(*c*) Sickle cell anaemia
(*d*) Haemophilia

104. The Royal's disease or haemophilia is due to the absence of

(*a*) factor-II
(*b*) factor-V
(*c*) factor-VIII
(*d*) factor-XI

105. What is true about test cross?

(*a*) It distinguishes homozygous and heterozygous dominants.
(*b*) It gives more chance for expression of the recessive trait.
(*c*) It helps to know the genotype of the unknown individual.
(*d*) All of the above

106. Gynaecomastia is seen in a man with

(*a*) Turner's syndrome
(*b*) Klinefelter's syndrome
(*c*) Down's syndrome
(*d*) Edward's syndrome

107. A couple has five daughters. The probability of 6^{th} child being son is

(*a*) 100%
(*b*) 75%
(*c*) 50%
(*d*) 9%

108. Chromosomal abnormality of intrauterine life can be detected by

(*a*) MRI
(*b*) amniocentesis
(*c*) ultrasound
(*d*) CT scanning

109. More human males suffer from colour blindness than females because

(*a*) in males, one defective gene is enough to make them colour blind

(*b*) the male sex hormone gives more chance for expressing the gene

(*c*) the females are more resistant to disease than male

(*d*) the colour blind gene is carried on the 'Y' chromosome

110. Genes for sex influenced characters are present on

(*a*) Y-chromosome (*b*) X-chromosome

(*c*) autosome (*d*) both (*a*) and (*b*)

111. The recessive genes present on X-chromosomes in humans are always

(*a*) expressed in males (*b*) expressed in females

(*c*) both (*a*) and (*b*) (*d*) lethal

112. Which of the following is the main reason behind Mendel's success?

(*a*) He analysed the data by applying principle of probability.

(*b*) He first studied only pair of contrasting characters at a time.

(*c*) He kept perfect pedigree record of his experiment.

(*d*) He grew different pea plants in different garden plots.

113. The F_2 genotypic ratio of Mendel's monohybrid cross is

(*a*) 1 : 1 : 1 : 1 (*b*) 3 : 1

(*c*) 9 : 3 : 3 : 1 (*d*) 1 : 2 : 1

114. The F_2 phenotypic ratio of Mendel's dihybrid cross is

(*a*) 1 : 1 : 1 : 1 (*b*) 3 : 1

(*c*) 9 : 3 : 3 : 1 (*d*) 1 : 2 : 1

115. Out of 800 F_2 offsprings of Mendel's dihybrid cross, the expected individuals of heterozygous for both the traits is

(*a*) 200 (*b*) 450

(*c*) 400 (*d*) None of these

116. Out of 800 F_2 offsprings of Mendel's dihybrid cross, the expected individuals of recessive for both the traits is

(*a*) 200 (*b*) 450

(*c*) 400 (*d*) None of these

117. Total number of progeny of a dihybrid cross is 1280 in F_2 generation. How many of these are dominant for both the traits?

(*a*) 240 (*b*) 360

(*c*) 720 (*d*) 480

118. Chromosomal theory of inheritance was given by

(*a*) Morgan (*b*) Morgan and Castle

(*c*) Sutton and Boveri (*d*) Correns

119. A hereditary disease which is never passed on from father to son is linked to

(*a*) Y-chromosome (b) X-chromosome

(*c*) autosome (*d*) none of these

120. How many types of gametes will be produced by an organism with genotype AaBbCc?

(*a*) 2 (*b*) 4

(*c*) 1 (*d*) 8

121. How many types of phenotypes will be produced in the cross AaBb × AaBb?

(*a*) 1 (*b*) 3

(*c*) 4 (*d*) 8

122. Mother's group is B and father has blood group A. Both are heterozygous. If they have identical twins, the percentage probability of both twins having blood group A is

(*a*) 100% (*b*) 50%

(*c*) 25% (*d*) 6.25%

123. Marriage in close blood relatives should be avoided because the offspring may receive

(*a*) two copies of dominant alleles

(*b*) two copies of same harmful recessive allele

(*c*) two deleted pieces of DNA

(*d*) none of these

124. Incomplete dominance is found in

(*a*) *Mirabilis* (*b*) *Antirrhinum*

(*c*) both (*a*) and (*b*) (*d*) none of these

125. A double heterozygous tall plant with yellow cotyledon is selfed. The ratio of dwarf plant with green cotyledon is

(*a*) 1/16 (*b*) 1/4

(*c*) 1/6 (*d*) 2/16

126. The dihybrid test cross ratio for quantitative trait is

(*a*) 1 : 2 : 1 (*b*) 1 : 1 : 1 : 1

(*c*) 9 : 3 : 3 : 1 (*d*) none of these

127. Both husband and wife have normal vision though their fathers are colour blind. The probability of their son becoming colour blind is

(*a*) 0% (*b*) 50%

(*c*) 25% (*d*) 75%

128. If the haploid chromosome number is 10, then the monosomic number shall be

(*a*) 18 (*b*) 11

(*c*) 9 (*d*) 19

129. Which of the following will give a ratio of a dihybrid test cross?

(*a*) Rr tt × Rr tt (*b*) Rr tt × rr Tt

(*c*) Rr Tt × rr Tt (*d*) None of these

130. In which generation the segregation of allelic phenotypes take place?

(*a*) F_0 (*b*) F_1

(*c*) F_2 (*d*) F_3

131. Inheritance of ABO blood group demonstrates the phenomenon of

(*i*) multiple allelism **(*ii*) polygeny**

(*iii*) co-dominance **(*iv*) pleiotropy**

(*a*) (*i*) and (*ii*) (*b*) (*ii*) and (*iii*)

(*c*) (*i*) and (*iv*) (*d*) (*i*) and (*iii*)

132. If a plant heterozygous for tallness is selfed, the F_2 generation has both tall and dwarf plants. It proves the principle of

(*a*) dominance
(*b*) segregation
(*c*) independent assortment
(*d*) incomplete dominance

133. Three children in a family have blood types O, AB and B respectively. What are the genotypes of their parents?

(*a*) $I^A I^A$ and $I^B I^0$
(*b*) $I^A I^O$ and $I^B I^O$
(*c*) $I^B I^B$ and $I^A I^A$
(*d*) None of these

134. Down's syndrome is caused by an extra copy of chromosome number 21. What percentage of offspring produced by an affected mother and a normal father would be affected by this disorder?

(*a*) 100%
(*b*) 25%
(*c*) 50%
(*d*) 0%

135. Turner's syndrome is represented by genotype

(*a*) 44+XO
(*b*) 44+XXY
(*c*) 44+XXX
(*d*) an extra chromosome in 21st pair

136. Which one of the following statements is correct?

(*a*) Homozygous sex chromosomes (ZZ) determine female sex in birds.
(*b*) XO type of sex chromosomes determine male sex in grasshopper.
(*c*) XO condition in human as found in Turner's syndrome determine female sex.
(*d*) Homozygous sex chromosomes (XX) produce male in *Drosophila*.

137. The dihybrid test cross ratio is

(*a*) 1 : 2 : 1
(*b*) 1: 1 : 1:1
(*c*) 9 : 3 : 3 : 1
(*d*) None of these

138. How many types of genotypes will be produced in the cross AaBb × AaBb?

(*a*) 2
(*b*) 9
(*c*) 8
(*d*) 4

139. Sex influenced characters are due to

(*a*) Y-linked genes
(*b*) Y-linked gene modification
(*c*) autosomal genes
(*d*) X-linked genes

Answers

1. (*a*)	**2.** (*c*)	**3.** (*d*)	**4.** (*c*)	**5.** (*b*)	**6.** (*a*)	**7.** (*b*)	**8.** (*a*)
9. (*a*)	**10.** (*d*)	**11.** (*b*)	**12.** (*d*)	**13.** (*b*)	**14.** (*d*)	**15.** (*b*)	**16.** (*d*)
17. (*c*)	**18.** (*c*)	**19.** (*b*)	**20.** (*c*)	**21.** (*a*)	**22.** (*b*)	**23.** (*b*)	**24.** (*a*)
25. (*d*)	**26.** (*d*)	**27.** (*d*)	**28.** (*c*)	**29.** (*a*)	**30.** (*b*)	**31.** (*b*)	**32.** (*d*)
33. (*d*)	**34.** (*b*)	**35.** (*b*)	**36.** (*b*)	**37.** (*c*)	**38.** (*b*)	**39.** (*d*)	**40.** (*d*)
41. (*a*)	**42.** (*d*)	**43.** (*b*)	**44.** (*b*)	**45.** (*d*)	**46.** (*b*)	**47.** (*a*)	**48.** (*c*)
49. (*b*)	**50.** (*b*)	**51.** (*d*)	**52.** (*c*)	**53.** (*b*)	**54.** (*a*)	**55.** (*d*)	**56.** (*b*)
57. (*a*)	**58.** (*a*)	**59.** (*d*)	**60.** (*c*)	**61.** (*b*)	**62.** (*a*)	**63.** (*c*)	**64.** (*b*)

65. (*d*)	**66.** (*a*)	**67.** (*a*)	**68.** (*a*)	**69.** (*a*)	**70.** (*c*)	**71.** (*b*)	**72.** (*b*)
73. (*c*)	**74.** (*b*)	**75.** (*c*)	**76.** (*c*)	**77.** (*a*)	**78.** (*a*)	**79.** (*a*)	**80.** (*d*)
81. (*b*)	**82.** (*d*)	**83.** (*b*)	**84.** (*a*)	**85.** (*c*)	**86.** (*b*)	**87.** (*d*)	**88.** (*c*)
89. (*c*)	**90.** (*a*)	**91.** (*c*)	**92.** (*d*)	**93.** (*a*)	**94.** (*d*)	**95.** (*a*)	**96.** (*d*)
97. (*a*)	**98.** (*d*)	**99.** (*b*)	**100.** (*d*)	**101.** (*a*)	**102.** (*a*)	**103.** (*c*)	**104.** (*c*)
105. (*d*)	**106.** (*b*)	**107.** (*c*)	**108.** (*b*)	**109.** (*a*)	**110.** (*c*)	**111.** (*a*)	**112.** (*b*)
113. (*d*)	**114.** (*c*)	**115.** (*a*)	**116.** (*d*)	**117.** (*c*)	**118.** (*c*)	**119.** (*d*)	**120.** (*d*)
121. (*c*)	**122.** (*c*)	**123.** (*b*)	**124.** (c)	**125.** (a)	**126.** (*a*)	**127.** (*c*)	**128.** (*b*)
129. (*b*)	**130.** (*c*)	**131.** (*d*)	**132.** (*b*)	**133.** (*b*)	**134.** (*c*)	**135.** (*a*)	**136.** (*b*)
137. (*b*)	**138.** (*b*)	**139.** (*c*)					

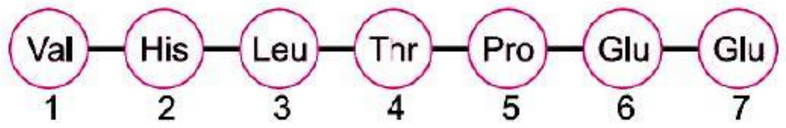
CASE-BASED QUESTIONS

Attempt any 4 sub-parts from each question. Each question carries 1 mark.

1. Read the following and answer the questions given below:

MUTATIONS LEAD TO GENETIC DISORDERS

A relevant portion of β-chain of haemoglobin of a normal human is given below:



The codon for the sixth amino acid is GAG. The sixth codon GAG mutates to GAA as a result of mutation 'A' and into GUG as a result of mutation 'B'. Haemoglobin structure did not change as a result of mutation 'A' whereas haemoglobin structure changed because of mutation 'B' leading to sickle shaped RBCs.

(*i*) Mutation 'B' changed the haemoglobin structure and not mutation 'A' because

(*a*) both GAG and GAA code for glutamic acid

(*b*) GAG codes for glutamic acid but GUG codes for valine

(*c*) reason cannot be predicted

(*d*) both (*a*) and (*b*)

(*ii*) What will be the genotype of an individual who is carrier of sickle-cell anemia gene but apparently unaffected?

(*a*) Hb^AHb^S (*b*) Hb^AHb^A

(*c*) Hb^SHb^S (*d*) None of the above

(*iii*) What will be the genotype of an individual affected with anemia?

(*a*) Hb^AHb^S (*b*) Hb^AHb^A

(*c*) Hb^SHb^S (*d*) Hb^SHb^A

(*iv*) Mutation is affected by

(*a*) temperature (*b*) immunity

(*c*) radiations (*d*) amount of sunlight

Answers

1. (*i*) (*d*) Due to mutation 'A', GAG mutates to GAA. But both GAG and GAA code for glutamic acid and hence there is no change in RBCs. Whereas GUG formed due to mutation 'B' codes for valine and so the RBCs become sickle-shaped.

(*ii*) (*a*) Hb^AHb^S

(*iii*) (*b*) Hb^SHb^S

(*iv*) (*c*) radiations

2. Read the following and answer the questions given below:

SICKLE-CELL ANEMIA

Sickle-cell anemia is a genetic disorder where the body produces an abnormal haemoglobin called haemoglobin S. Red blood cells are normally flexible and round, but when the haemoglobin is defective, blood cells take on a "sickle" or crescent shape. Sickle cell anemia is caused by mutations in a gene called HBB. It is an inherited blood disorder that occurs if both the maternal and paternal copies of the HBB gene are defective. In other words, if an individual receives just one copy of the defective HBB gene, either from mother or father, then the individual has no sickle cell anemia but has what is called "sickle cell trait". People with sickle cell trait usually do not have any symptoms or problems but they can pass the mutated gene onto their children. There are three inheritance scenarios that can lead to a child having sickle cell anemia:

- Both parents have sickle cell trait
- One parent has sickle cell anemia and the other has sickle cell trait
- Both parents have sickle cell anemia

(*i*) Sickle-cell anemia is a/an _____ disease.

(*a*) X linked (*b*) autosomal dominant

(*c*) autosomal recessive (*d*) Y linked

(*ii*) If both parents have sickle cell trait, then there is _____ of the child having sickle cell anemia.

(*a*) 25 % risk (*b*) 50% risk

(*c*) 75% risk (*d*) no risk

(*iii*) If both parents have sickle-cell trait, then there is _____ of the child having sickle cell trait.

(*a*) 25% risk (*b*) 50% risk

(*c*) 75% risk (*d*) no risk

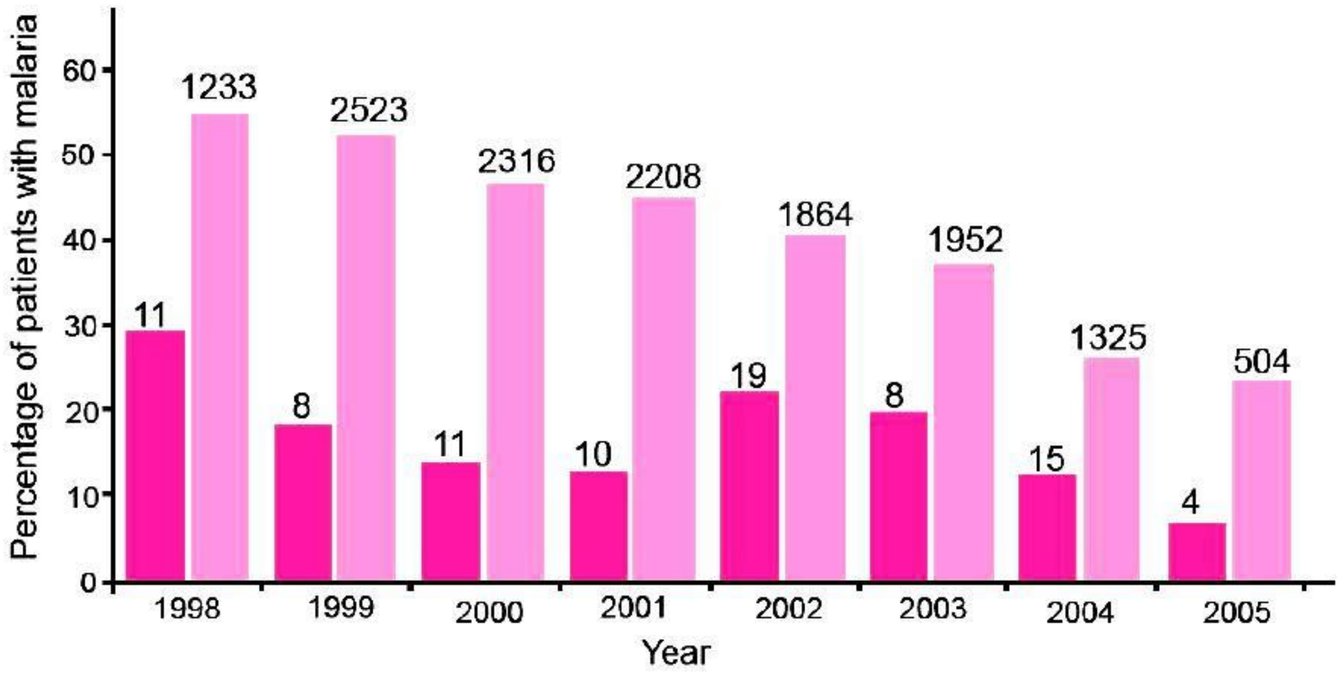
(*iv*) If one parent has sickle-cell anemia and the other has sickle cell trait, there is _____ that their children will have sickle cell anemia and _____will have sickle-cell trait.

(*a*) 25 % risk, 75% risk (*b*) 50 % risk, 50% risk

(*c*) 75% risk, 25% risk (*d*) no risk

(*v*) The following statements are drawn as conclusions from the below data (Kenya).

1. Patients with SCD (Sickle Cell Disease) are less likely to be infected with malaria.
2. Patients with SCD (Sickle Cell Disease) are more likely to be infected with malaria.
3. Over the years the percentage of people infected with malaria has been decreasing.
4. Year 2000 saw the largest percentage difference between malaria patients with and without SCD.



Choose from below the correct alternative.

(*a*) only 1 is true
(*b*) 1 and 4 are true
(*c*) 3 and 2 are true
(*d*) 1 and 3 are true

Answers

2. (*i*) (*c*) autosomal recessive
(*ii*) (*a*) 25% risk
(*iii*) (*b*) 50% risk
(*iv*) (*b*) 50% risk, 50% risk
(*v*) (*d*) 1 and 3 are true

3. Read the following and answer the questions given below:

TURNER'S SYNDROME

Turner's syndrome is an example of monosomy. It is formed by the union of an allosome free egg and a normal 'X' containing sperm or a normal egg and an allosome free sperm. The individual has $2n = 45$ chromosomes (44 + XO) instead of 46. Such individuals are sterile females who have rudimentary ovaries, under-devloped breasts, small uterus, short stature, webbed neck and abnormal intelligence. They may not menstruate or ovulate. Individuals with Turner's syndrome have deficiency of FSH and oestrogen secretion. This disorder can be treated by giving female sex hormone to the women from the age of puberty to make them develop breasts and have menstruation. This makes them feel more normal.

(*i*) Number of Barr bodies in females with Turner's syndrome is

(*a*) zero
(*b*) one
(*c*) two
(*d*) more than two

(*ii*) Turner's syndrome is an example of

(*a*) aneuploidy
(*b*) euploidy
(*c*) polyploidy
(*d*) autosomal abnormality

(*iii*) Female with Turner's syndrome

(*a*) are always sterile
(*b*) are always fertile
(*c*) may be sterile or fertile
(*d*) can be made fertile by injecting female hormone regularly

(*iv*) Which of the following statement regarding Turner's syndrome is not correct?

(*a*) It is a case of monosomy of sex chromosomes.

(*b*) The suffering individual is sterile female will one 'X' chromosome missing in the cells.

(*c*) The problem can be cured by taking regular injection of female sex hormone after puberty.

(*d*) The individuals are of short stature.

Answers

3. (*i*) (*a*) zero

(*ii*) (*a*) aneuploidy

(*iii*) (*a*) are always sterile

(*iv*) (*c*) The problem can be cured by taking regular injection of female sex hormone after puberty.

4. Read the following and answer the questions given below:

SEX-DETERMINATION IN HONEY BEES

In case of honey bee, the male is haploid while the female is diploid. Similar conditions are found in some other insects like ants and wasps. Male insects are haploid because they develop parthenogenetically from unfertilised eggs. The phenomenon is called arrhenotoky. Meiosis does not occur in the formation of sperms. Females grow from fertilized egg and are hence diploid.

Queen bee picks up all the sperms from drone during nuptial flight and stores them in seminal receptacle. When the queen visits drone cells it lays eggs but seminal receptacles fails to emit the sperms. The male honey bee develops parthenogenetically from these unfertilised eggs. However in all other cells, *i.e.*, cells of workers, the female lays eggs and sperms are emitted properly from its seminal receptacle, upon these eggs leading to their fertilization. Hence except drones other honey bees (worker and queen) are diploid.

(*i*) The $2n$ number of chromosomes for honey bee is 32. How many chromosomes will be present in the cells of drone?

(*a*) 64 (*b*) 32

(*c*) 16 (*d*) 8

(*ii*) The purpose of queen and drone for performing nuptial flight is

(*a*) to estabilish a new life (*b*) to perform copulation

(*c*) to collect pollen and necter (*d*) all of these

(*iii*) What type of cell division is involved in spermatogenesis in honey bee?

(*a*) Meiosis (*b*) Endomitosis

(*c*) Mitosis (*d*) None of these

(*iv*) Which of the following factors is responsible for the fertilized eggs to develop into queen or worker?

(*a*) Amount of temperature for incubation of eggs

(*b*) Type of nutrition given to the larvae

(*c*) Type of sperm performing fertilization of eggs

(*d*) All of these

(*v*) **Parthenogenetic development of drone is an example of**

(*a*) arrhenotoky (*b*) gynogenic haploid

(*c*) androgenic haploid (*d*) both (*a*) and (*b*)

Answers

4. (*i*) (*c*) 16

(*ii*) (*b*) to perform copulation

(*iii*) (*c*) Males produce sperms by mitosis.

(*iv*) (*b*) Non-fertilised eggs will develop into drones and fertilized will develop into female individuals which will further develop into queen or workers depending upon their nutrition during their larval stage.

(*v*) (*d*) both (*a*) and (*b*)

ASSERTION-REASON QUESTIONS

In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

1. Assertion : The law of independent assortment can be studied through dihybrid cross.
Reason : Only those genes show independent assortment which are linked.

2. Assertion : Mendel successfully conducted his hybridisation experiments.
Reason : Garden pea was an ideal experimental material.

3. Assertion : In a monohybrid cross, only dominant characters exhibit themselves in the F_1 generation.
Reason : Dominant trait is expressed only in the heterozygous condition.

4. Assertion : ABO blood group system is a good example of pleiotropic genes.
Reason : In ABO blood group system, when I^A and I^B alleles are present together, both express themselves.

5. Assertion : In birds, females are heterogametic and males are homogametic.
Reason : In birds, females have ZW sex chromosomes and males have ZZ sex chromosomes.

6. Assertion : The maximum frequency of recombination that results from crossing over of linked genes is 50 percent.
Reason : If distance between linked genes is longer, they show higher frequency of crossing over.

7. Assertion : Down's syndrome is caused due to absence of either X or Y sex chromosome.
Reason : Such individuals show mental retardation and broad head with characteristic features.

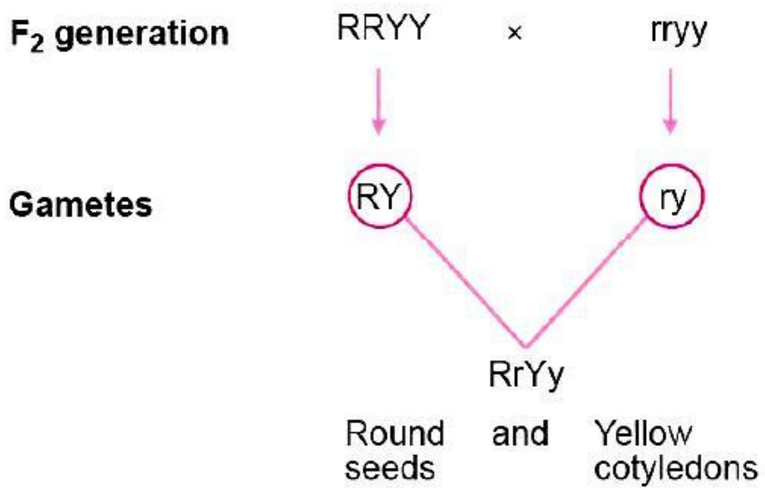
8. **Assertion** : Sickle-cell anaemia is an autosome-linked recessive disorder.
   Reason : It appears only in human male which can be transferred to their grandson through carrier daughter.
9. **Assertion** : Haemophilia never occurs in women.
   Reason : Gene for haemophilia is located on X chromosome.
10. **Assertion** : The genetic complement of an organism is called genotype.
    Reason : Genotype is the type of hereditary properties of an organism.

Answers

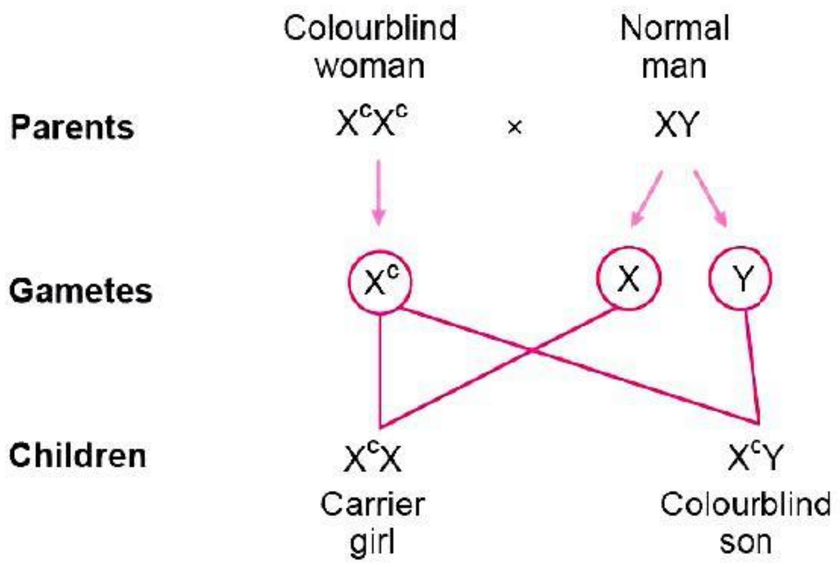
1. (*c*) **2.** (*b*) **3.** (*c*) **4.** (*a*) **5.** (*a*) **6.** (*b*) **7.** (*d*) **8.** (*c*)
9. (*c*) **10.** (*a*)

HINTS/EXPLANATIONS OF SELECTED MCQs

2. (*c*)



4. (*c*)



8. (*a*) Aneuploidy refers to the condition when the chromatids fail to segregate during cell division, resulting in gain or loss of a chromosome.

15. (*b*)

Parents Tall Tt × Tall Tt

Gametes T, t and T, t

Offsprings

♀ \ ♂	T	t
T	TT Tall	Tt Tall
t	Tt Tall	tt Dwarf

Tall : Dwarf : : 3 : 1

18. (*c*) **Possibilities:**

Parents Mother $I^B I^O$ × Father $I^A I^O$

Gametes I^B, I^O and I^A, I^O

Offsprings: $I^A I^B$, $I^B I^O$, $I^A I^O$, $I^O I^O$

Blood group AB, B, A, O

Parents Mother $I^B I^O$ × Father $I^B I^O$

Gametes I^B, I^O and I^B, I^O

Offsprings: $I^B I^B$, $I^B I^O$, $I^B I^O$, $I^O I^O$

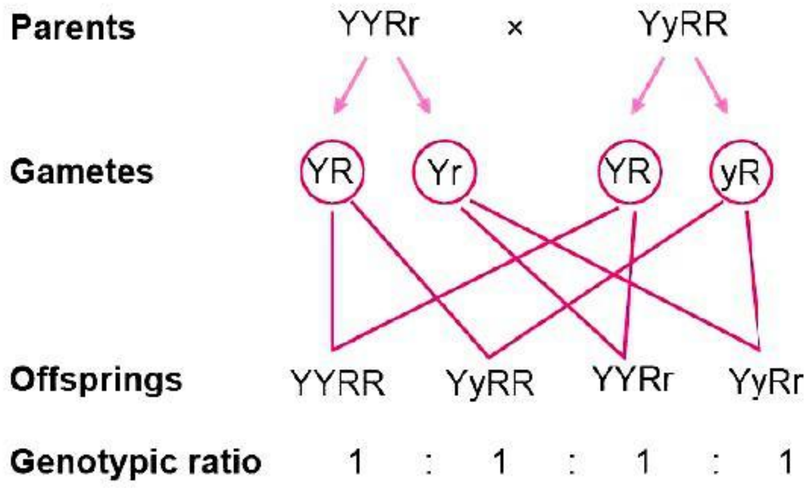
Blood group B, B, O

32. (*d*) The genes controlling the seven pea characters studied by Mendel are now known to be located on 4 different chromosomes (1, 4, 5, 7) and not on 7 chromosomes. Genes for seed colour and flower colour are located on chromosome 1. Genes for height, inflorescence and pod shape are located on chromosome 4. Gene for pod colour are located on chromosome 5. Gene for seed shape is located on chromosome 7.

33. (*d*) Four haploid daughter cells which are formed as a result of meiosis will differ from each other. It happens because of crossing over where the characters undergo recombination. Independent assortment of characters into gametes during sexual reproduction also plays the significant role in producing genetic variation.

51. (*d*) Mendel worked with seven distinct characteristics of pea plants; plant height, pod shape and colour, seed shape and colour, and flower position and colour.

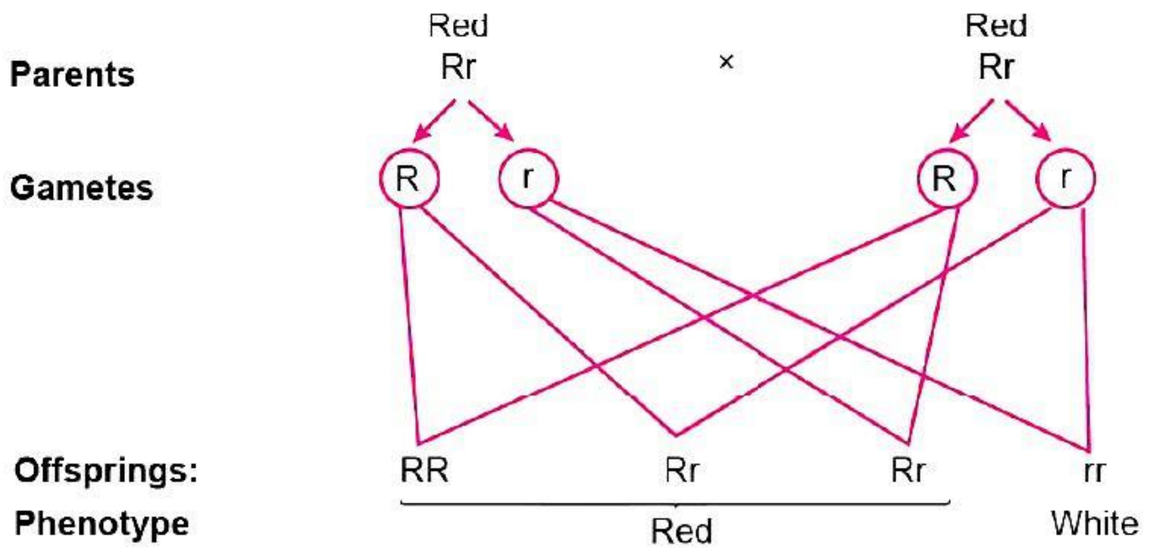
55. (*d*)



56. (*b*) Blood group B would be possible only if the man has genotype $I^A i$.

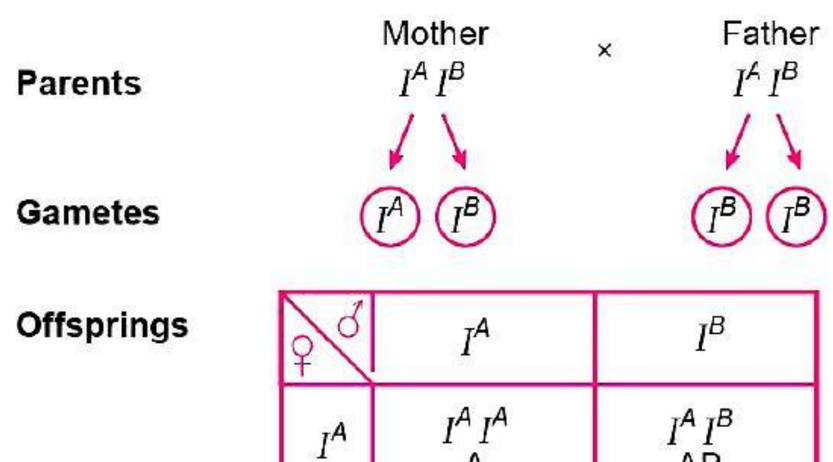
57. (*a*) Since albinism is a recessive character, a child will be albino only if it is homozygous for albinism genes. Since parents have normal skin, it means they are heterozygous. As a result of cross between two heterozygous parents, 25% of the children will be homozygous recessive. The nature of the third child is not affected in any way by the nature of the first or second child because all are independent events.

58. (*a*)



Out of 1600 seeds produced $\frac{3}{4}$th or 75% will be red, *i.e.*, $\frac{3}{4} \times 1600 = 1200$ seeds.

59. (*d*)



Offsprings

♀ \ ♂	I^A	I^B
I^A	$I^A I^A$ A	$I^A I^B$ AB
I^B	$I^A I^B$ AB	$I^B I^B$ B

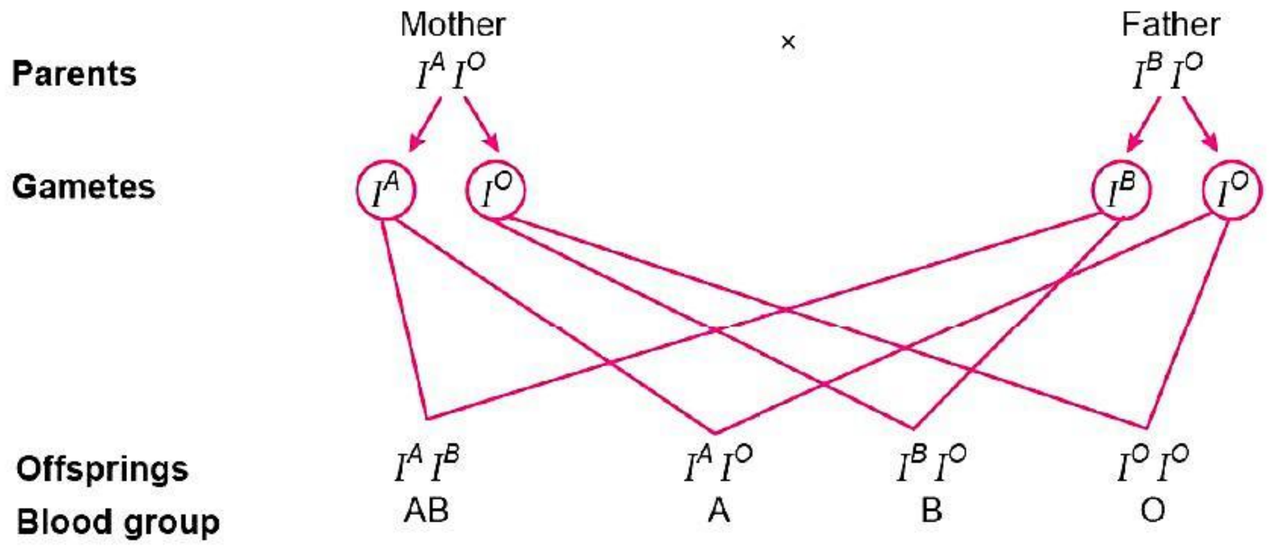
Phenotype Blood group A : Blood group AB : Blood group B
1 : 2 : 1

Possibility of blood group AB = $\frac{1}{2}$

62. (*a*) A man with genotype AaBb will produce four gametes : AB, Ab, aB and ab; all with equal probabilities of $\frac{1}{4}$ or 25%.

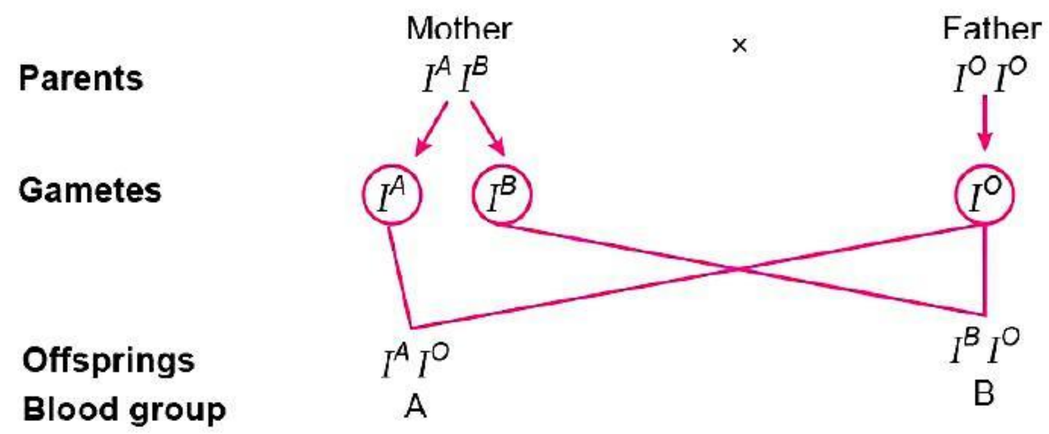
So, out of 10 million sperms, $\frac{1}{4} \times 10 = 2.5$ million will have both recessive allele.

66. (*a*)



Probability of blood group O child is $\frac{1}{4}$.

67. (*a*)



Probability of blood group A child is $\frac{1}{2}$.

68. (*a*) Refer to the cross in Q. 67.

Probability of blood group AB child = 0.

69. (*a*) Refer to the cross in Q. 67.

Probability of blood group A child is $\frac{1}{2}$.

70. (*c*) Each parent will produce 32 allele combinations. This means that the Punnett square will have 32 rows and 32 columns.

$$32 \times 32 = 1024 \text{ cells}$$

71. (*b*) The formula for genotype calculation is given by 3^n. The formula for phenotype calculation is given by 2^n.

If there are 81 genotypes, then $3^n = 81$

'81' can be written as 3^4.

Therefore, $n = 4$

Count of phenotypes = $2^n = 2^4 = 16$

72. (*b*) Number of phenotypes = 2^n (where n = number of recessive alleles)

Here, $n = 4$

So, number of phenotypes = $2^4 = 16$

74. (*b*) A male inherits an X chromosome from his mother and a Y chromosome from his father.

75. (*c*) A female inherits one X chromosome from her mother and one X chromosome from her father. Males normally have an X and a Y chromosome (XY). A male inherits an X chromosome from his mother and a Y chromosome from his father.

92. (*d*) Sex limited inheritance refers to the inheritance of traits that are expressed only in either the male or the female offspring due to their expression being influenced by differences in the anatomy of males and females. For example, if a trait is displayed in organs present only in females, even though a male also inherits the gene, it would not show in him.

Sex influenced inheritance is the difference in display of traits due to a differing biological environment as males and females like the presence of specific sex hormones. For example, the genes that result in baldness may be present in both males as well as in females but are more likely to be expressed in males as a result of the male sex hormones.

Sex linked inheritance is traits carried in either the X or the Y chromosome. A trait that is due to genes present on the X chromosome is more likely to be expressed in males as they have only one X chromosome.

93. (*a*) Normally, flies have either one or two X chromosomes and two sets of autosomes. If there is one X chromosome in a diploid cell (1X:2A), the fly is male. If there are two X chromosomes in a diploid cell (2X:2A), the fly is female (Bridges 1921, 1925). Thus, XO *Drosophila* are sterile males.

94. (*d*) The sex chromosomes in birds are designated Z and W, and the male is the homomorphic sex (ZZ) and the female heteromorphic (ZW). In most avian species the Z chromosome is a large chromosome, usually the fourth or fifth largest, and it contains almost all the known sex-linked genes.

100. (*d*) **Parents** HhYy × HhYy

Gametes HY Hy hY hy | HY Hy hY hy

Offsprings:

♀ \ ♂	HY	Hy	hY	hy
HY	HHYY	HHYy	HhYY	HhYy
Hy	HHYy	HHyy	HhYy	Hhyy
hY	HhYY	HhYy	hhYY	hhYy
hy	HhYy	Hhyy	hhYy	hhyy

101. (*a*) The possible genotypes by T and t are:

TT, Tt, tt

103. (*c*) Pleiotropy is the ability of a gene to have multiple phenotypic effects.

115. (*a*) As per Mendel's dihybrid cross 1/4th individuals of population of given number would be heterozygous for both the traits.

116. (*d*) As per Mendel's dihybrid cross genotype, 1% individuals of population of given number would be homozygous recessive for both the traits.

117. (*c*) The seeds with dominant for both the traits means the seed must be round and yellow and as per mendelian dihybrid cross there were such 9 seeds out of total 16 seeds. (9: 3: 3 :1).

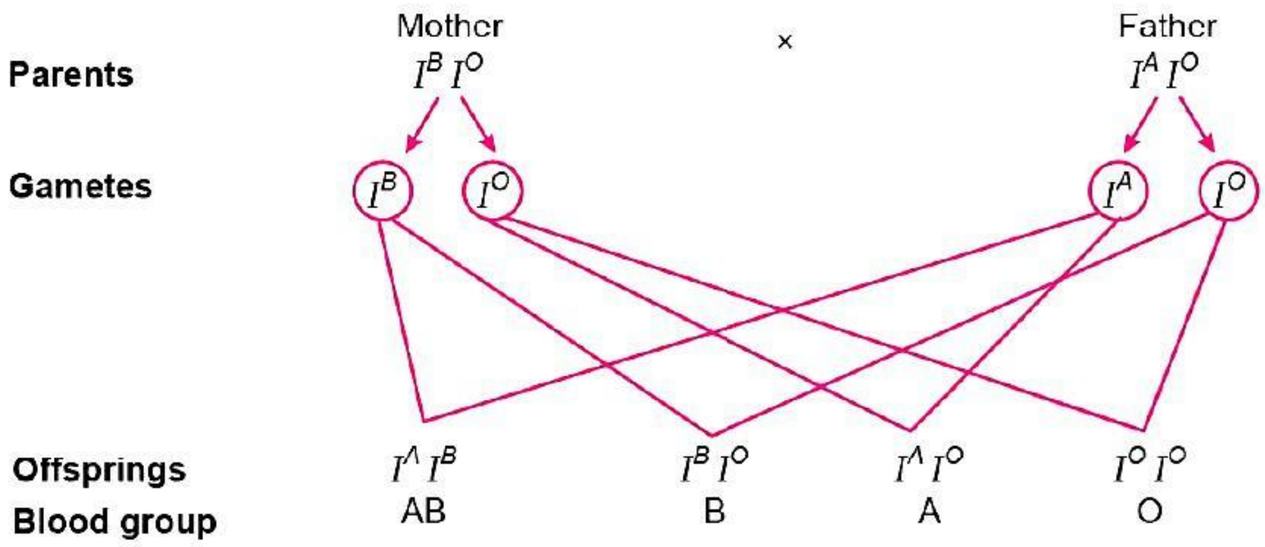
So, the seeds dominant for both the traits can be = $\frac{9}{16} \times 1280 = 720$.

120. (*d*) To determine possible gametes we can use equation = 2^n

n is the number of heterozygous gene pairs. Here, n will be 3.

So, number of gametes would be $2^3 = 8$

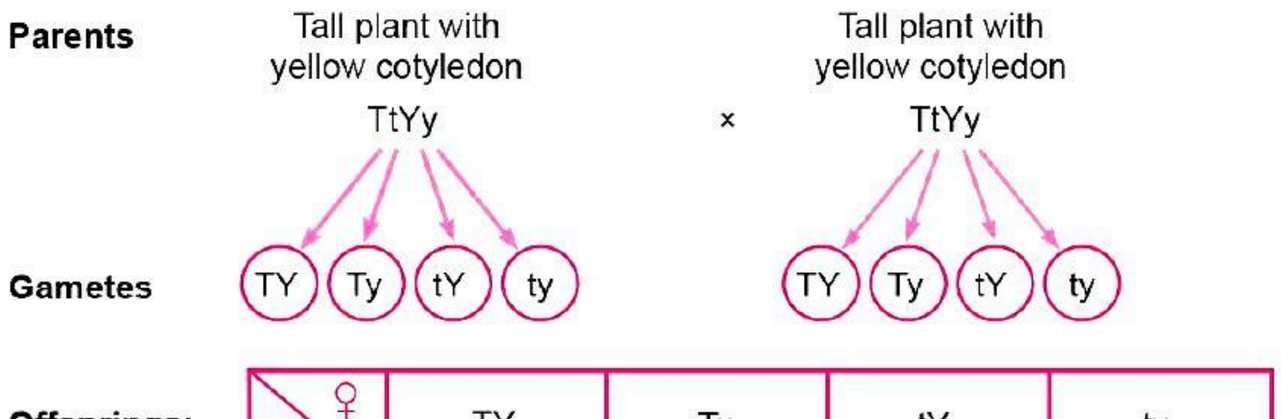
122. (*c*)



Probability of twins having blood group A = $\frac{1}{4}$.

123. (*b*) Marriage between related individuals is risky. It is because the recessive alleles in the gene pool will accumulate. If the recessive allele, which reaches the female individual is heterozygous, female is called as carrier. Then the gene gets transferred to further generations, and in male child the defective gene will be expressed to cause the disease.

125. (*a*)

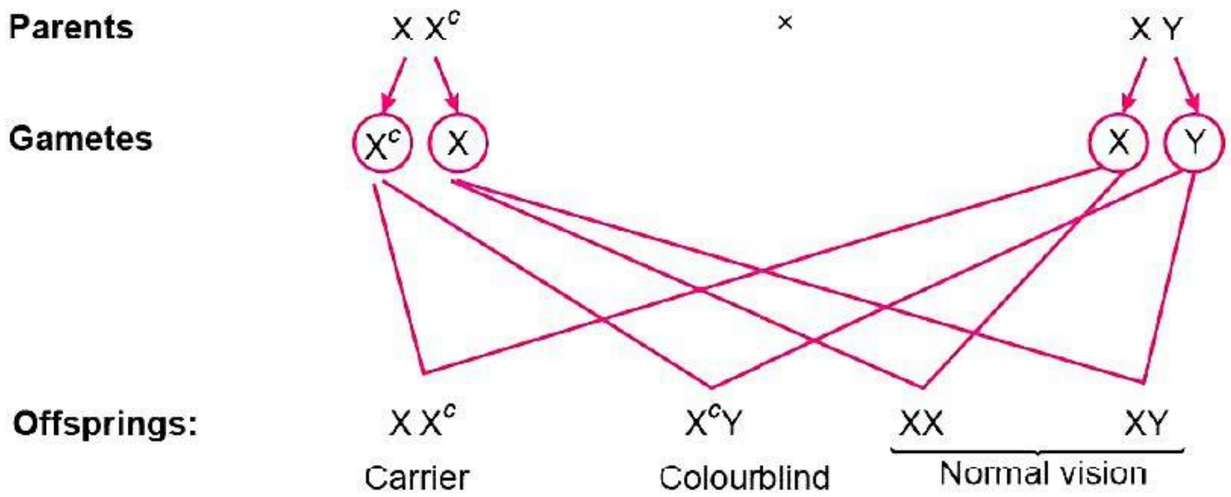


Offsprings:

♀ / ♀	TY	Ty	tY	ty
TY	TTYY	TTYy	TtYY	TtYy
Ty	TTYy	TTyy	TtYy	Ttyy
tY	TtYY	TtYy	ttYY	ttYy
ty	TtYy	Ttyy	ttYy	ttyy

Ratio of dwarf plant with green cotyledon is $\frac{1}{16}$.

127. (*c*) Since the grandfathers were colourblind, the gene X^c for colourblindness has been passed on to the mother (who is a carrier) and not to the father (normal visioned).



The probability of son being colourblind is $\frac{1}{4}$ or 25%.

128. (*b*) In Mendel's experiments, the segregation and the independent assortment during meiosis in the F_1 generation give rise to the F_2 phenotypic ratios observed by Mendel.

134. (*c*) Down's syndrome is an autosomal disease caused due to the trisomy of the 21st chromosome as a result of non-separation of chromosomes. Trisomy 21 can result from non-separation of the chromosomes in the mother, non-separation in the father, and after the egg and sperm have merged. It is a chromosomal disorder so is neither dominant nor recessive. As it is an autosomal disorder, so it does not matter whether male parent is affected or female parent. Thus, if the mother is affected, then there are 50% chances of having offspring with Down's syndrome, as two types of gametes are produced by affected mother (one with normal number of gametes and other with abnormal number of gametes)

138. (*c*) The number of genotypes can be calculated by the formula 3^n (where n = number of recessive alleles)

So, types of genotypes = $3^2 = 9$.